

ACCESSION #: 9604220352

LICENSEE EVENT REPORT (LER)

FACILITY NAME: Oconee Nuclear Station, Unit Three PAGE: 1 OF 28

DOCKET NUMBER: 05000287

TITLE: Loss Of Feedwater Results In Reactor Trip Due To
Installation Deficiency

EVENT DATE: 03/16/96 LER #: 96-01-00 REPORT DATE: 04/15/96

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: N POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10
CFR SECTION:
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:

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COMPONENT FAILURE DESCRIPTION:

CAUSE: SYSTEM: COMPONENT: MANUFACTURER:

REPORTABLE NPRDS:

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On March 16, 1996, during a Performance Test of the Emergency Power System, an unexpected closure of certain Unit 3 relay contacts occurred due to vibration. This caused a momentary load shed signal that resulted in the loss of several secondary system pumps, which initiated a feedwater transient. At 1318 hours, Unit 3 tripped from 100% full power on a Reactor Protective System (RPS) anticipatory trip due to the loss of Main Feedwater Pumps. All Emergency Feedwater pumps started and supplied the Steam Generators. Unit 3 was powered from the emergency power source and all the Reactor Coolant Pumps (RCP) tripped off, as expected due to the test conditions. The Unit was stabilized on natural circulation. The reactor trip was caused by a condensate system transient resulting from the load shed of 4KV Bus 3TE. The root cause of the event was determined to be Installation Deficiency due to improper assembly of a relay. Subsequently, on March 17, 1996, at Hot Shutdown, a RPS automatic actuation occurred, with no control rods withdrawn, when one of the two operating RCPs was tripped due to high vibration. Corrective actions included replacing and properly installing the relay and revising procedures.

END OF ABSTRACT

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BACKGROUND

Each Oconee unit is provided with several sources of normal and backup electrical power. The Start-up and Stand-by Sources are part of the Emergency Power System [EIS:EB] as described below.

The Normal source of power for an operating Oconee Unit is from the

unit's generator via the Auxiliary Transformer (1T, 2T, or 3T). The Auxiliary Transformer provides 6900V power [EIS:EA] for operating Reactor Coolant Pumps (RCPs), and 4160V power to two main Feeder Buses (MFBs) for the rest of the normal loads.

The Start-up source of power is from the 230 KV Switchyard (SWYD) [EIS:FK] via the unit's Start-up transformer (CT1, CT2, or CT3), and it also provides both 6900V power for RCPs and 4160V power to the MFBs.

The Stand-by source can receive power from the underground feeder from Keowee Hydro (KH) Station [EIS:EK], via CT4 or from the Central Switchyard via CT5. The underground feeder and associated transformer (CT4) are sized to carry full Engineered Safeguards [EIS:JE] loads of one Oconee unit plus the auxiliary loads required for safe shutdown of the other two Oconee units. However, the Stand-by source only provides 4160V power to the MFBs and cannot provide 6900V power for RCPs.

Each Oconee unit's power sources are monitored by the Emergency Power Switching Logic (EPSL) and the Main Feeder Bus Monitor Panels (MFBMP). EPSL will monitor the voltage available to the Normal Source, and will initiate a breaker trip to isolate the Normal Source if an undervoltage condition exists. it will then attempt to transfer to the Start-up Source by closing the Startup breakers if voltage is available there. For events, such as a unit trip, this transfer is all that is necessary to provide uninterrupted power to station loads.

In the event that power is not available via the Start-up Source, due to a Loss of off-site Power (LOOP), the MFBMP will initiate automatic actions to provide power. The Stand-by Bus is not normally energized, but, after a 20 second time delay, the MFBMP will automatically emergency start KH, and actuate EPSL to loadshed unnecessary loads, and connect one KH unit to the Stand-by Buses. After an additional 10 second time delay, EPSL will initiate Stand-by Breaker closure to energize the MFBs from the Stand-by Buses.

Per Technical Specifications (TS), offsite power must be available from the system grid via the Oconee 230 KV SWYD. The SWYD (see Attachment 1) has two electrical buses and a number of circuit breakers that connect the generators with the transmission system. The buses provide junction points for the power exchange between generators and the system. The SWYD can receive power from the generator output transformers for Oconee Units 1 and 2, and Keowee Hydro Station. In addition, the SWYD can supply power to the Start-up transformers for Oconee Units 1, 2, and 3. The SWYD also connects to four pairs of 230 KV transmission lines (Jocassee, Dacus, Oconee, and Calhoun) and via the autobank transformer to the 525 KV SWYD that connects the Oconee Unit 3 generator to the 525 KV distribution system.

In the SWYD, Power Circuit Breakers (PCBs) control the flow of AC power and isolate any section that may be faulted. The SWYD is arranged in a breaker-and-a-half scheme, so called because three PCBs are used to connect two circuits. The two SWYD buses are designated as the RED bus and the YELLOW bus. Each PCB is designated with a number as shown on Attachment 1.

Keowee Hydro Station consists of two hydroelectric generators [EIS:GEN],

Air Circuit Breakers (ACBs) 1 through 4, the Main Step-up transformer, auxiliary power load centers 1X and 2X, and associated support equipment and auxiliaries. (See Attachment 2.)

The "overhead" emergency power path is from one KH unit, through the unit overhead generator breaker (ACB-1 or 2), the main step-

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up transformer through PCB-9, the switchyard yellow bus, the applicable Oconee unit startup transformer (CT-1, 2, or 3), and the associated startup breakers (E1 and E2) to the main feeder buses. An External Grid Protective System monitors voltage and frequency on the RED and YELLOW buses, and the Degraded Grid System monitors the voltage at the startup transformers to detect a SWYD or grid disturbance. If voltage or frequency is degraded on both buses or an undervoltage condition exists on two of the three startup transformers for 9 seconds concurrent with an Engineered Safeguard (ES) signal on any Oconee unit, the system initiates. It isolates the SWYD by tripping appropriate PCBs, starting both KH units, and aligning the SWYD to distribute power from the appropriate KH unit to the startup transformers via the YELLOW bus.

The "underground" emergency power path is from the second KH unit, through the unit underground generator breaker (ACB-3 or 4), an underground feeder, transformer CT-4, the CT-4 feeder breakers (SK-1 and SK-2), the standby buses (SEB), and unit standby breakers (S1 and S2) to the MFBs. This underground feeder is connected, at all times, to one KH generator on a predetermined basis and is energized along with CT-4 whenever the associated KH unit is in service.

Each KH unit is provided with its own automatic start equipment. Both units undergo a simultaneous automatic start and run in standby on a loss of the grid, an ES actuation on any of the three Oconee Units, or an extended loss of voltage on any unit's MFBs. On an emergency automatic start, the unit connected to the underground feeder supplies that feeder while the other unit, remaining in standby, is available to supply the overhead path. If there is a grid disturbance, the "overhead" unit is automatically connected to the Oconee SWYD YELLOW bus after SWYD isolation as described above. Therefore, in the event of a LOCA/LOOP or degradation of the grid, emergency power is available from either KH unit through the underground path and/or the overhead path.

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The Oconee 230 KV SWYD has an undervoltage relaying system that can separate the auxiliaries from offsite power supplies if they experience degraded conditions. The Degraded Grid Protection system monitors the voltage on the startup transformers for all three units. When a degraded voltage is sensed for 9 seconds, concurrent with an ES signal on any Oconee unit, the system isolates the startup transformers from the system grid and aligns them to one of the KH Units.

Power can be made available to the standby power buses from one of the Lee Steam Station combustion turbines (CT). The power is provided through a 100 KV transmission line from the Lee CT's via the Central SWYD to Oconee's CT-5 transformer. If an emergency occurs that would require the use of this 100 KV line it can be isolated from the balance of the transmission system in order to Supply power to Oconee. One of the Lee CT's can be started and supply power within one hour. An alternate power alignment is from the Central Switchyard, which has been modified to

include relaying for degraded grid protection. Use of Central SWYD as an emergency power source is allowed by the station's abnormal procedures as a last resort for restoring power.

The Condensate System [EIS:SD] originates at the Condenser Hotwell (see Attachment 3). The Hotwell Pumps supply Condensate to the Polishing Demineralizers, Condensate Coolers, Generator Hydrogen and Water Coolers, and Air Ejectors before entering the Condensate Booster Pumps (CBP). The CBPs increase system pressure to that required for the Main Feedwater Pump (MFDWP) net positive suction head.

The Emergency Feedwater [EIS:BA] system will actuate on loss of both MFDWPs. One of the trips of the MFDWPs is low suction pressure (260 psig).

The Integrated Control System (ICS) [EIS:JA] provides fully automatic control of reactor power, steam generation rate, and generated load by processing selected signals of measured plant parameters.

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The term tracking is used to define the mode of operation when, due to some abnormal condition, some portion of the ICS cannot follow the Unit Load (automatic) demand. In order to maintain coordination of all the control variables, the system must track or follow the abnormal conditions. The actual generated megawatts is used as an indication of the independent variable and is used as the unit load demand. one of the conditions that causes tracking is transferring the turbine control station to manual. When this station is in manual, turbine control is not tied to the remainder of the unit. In order to maintain coordination

of the unit, the unit load demand will follow the actual megawatts generated, which is a function of the turbine control station.

The total feedwater flow must be maintained within a certain ratio of the reactor power. The ICS uses Cross Limits as the method of controlling this ratio regardless of the unit load demand. If reactor power changes to a point such that the neutron power is more than 5% different from the neutron power demand, the feedwater control will respond to this change in neutron power. Feedwater flow demand signal is modified to maintain the proper ratio between feedwater flow and reactor power.

The Reactor Protective System (RPS) [EIS:JC] is a Nuclear Safety Related system designed to protect the fuel and fuel cladding from damage. The RPS monitors selected plant parameters related to safe plant operation and trips the reactor when predetermined setpoints are reached on two-out-of-four independent channels. During shutdown, the RPS is placed in shutdown bypass mode. The shutdown bypass switch enables several trip parameters to be bypassed, allowing control rod withdrawal after the reactor has been shut down and depressurized below the low Reactor Coolant System (RCS) [EIS:AB] pressure trip setpoint (1810 psig.).

One of the trip parameters of the RPS is Flux to Flow minus the Imbalance ratio. The STAR hardware processes the RCS flow signals, to provide inputs to the Flux/Imbalance/Flow (FIF) trip algorithm and RCS flow outputs for the plant computer.

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Installation of the STAR hardware is a recent modification in the FIF trip string of the RPS. The STAR trip algorithm is designed to trip if

either RCS loop flow is zero. This is independent of the power level or power imbalance.

EVENT DESCRIPTION

All the Oconee units were operating at 100% full power on the morning of March 16, 1996, when a Periodic Test (PT) (Degraded Grid, Switchyard Isolation and Keowee Overfrequency Protection Functional Test) was scheduled to be performed. The test was to:

1. Functionally verify Keowee ACB 1, 2, 3, and PCB 9 operation during switchyard isolation and Keowee Emergency Start.
2. Demonstrate operability of Degraded Grid Protection System.
3. Demonstrate ability of Keowee Units to energize the 230 KV Yellow Bus, all 3 units' startup transformers and the underground path.
4. Functionally verify a Modification (NSM ON-52966).

This PT is performed on an 18 month frequency and was treated as an infrequent evolution that required management oversight.

The initial conditions for the test had been established during the morning and numerous pre-job briefings were completed with all the required individuals and crews. At 1150 hours, March 16, 1996, the Operation Shift Manager (OSM) entered a 72 hour Limiting Condition for Operation (LCO) on all Oconee units for the Overhead Path taken out of service in accordance with Technical Specifications (TS). Both of the Keowee units were then started and loaded to approximately 74 megawatts each, generating power to the Duke Power grid. The OSM then entered into another 72 hour LCO at 1258 hours due to the Startup Transformers, CT1, CT2, and CT3, being separated from the red bus.

All of the 4160V and 6900V switchgear auto/manual switches on each Oconee unit were placed in manual as a precaution to block a rapid transfer of the switchgear should a Unit trip occur. The DC supply breaker to the channel 1 degraded grid protection system logic was opened as part of the test to ensure that channel 2 alone would actuate all appropriate functions. PT step 12.13.6 (simultaneously depress and hold Unit 1 and Unit 2 CT undervoltage relay pushbuttons) was completed at approximately 1317 hours, creating the conditions to simulate degraded grid voltage for the 2 out of 3 logic in the degraded grid protection system. ACB's 1, 2, 3 (ACB-4 was already open) and PCB 9 opened as they should and later at the appropriate time, these breakers reclosed (not ACB-1 or 4) such that Keowee 1 was feeding the underground path and Keowee 2 was feeding the overhead path.

At 13:17:47 hours, which was within 1 second of the alarms for the degraded grid relay actuations (as recorded on the unit 3 alarm typer), all of the closed "load shed" breakers in the 3TE switchgear tripped. This included the 3C Condensate Booster Pump (CBP), 3C Hotwell Pump (HWP), 3D1 Heater Drain Pump (HDP), the 3E1 HDP, and the 3X3 Feeder Breaker. No other Unit 1, 2 or 3 4160V switchgear breakers opened. The tripping of these Condensate and Heater Drain Pumps induced a severe feedwater transient on Unit 3 which was operating at 100% full power.

The Operators noticed immediately that loads were lost on 3TE and that the unit was in a feedwater transient. Low pressure alarms were received on the Main Feedwater Pumps (MFDWP) discharge. Suction flow to the MFDWPs decreased due to the loss of 3C CBP, 3C HWP, 3D1 HDP, and the

3E1

HDP. Valves 3C-14 and 3C-15 (Powdex Bypass) automatically opened and the standby 3B CDP started due to low MFDWP suction pressure (360 psig). The Unit received a turbine runback signal due to an indicated loss of Stator Cooling signal that was generated when 3TE load shed. Stator Cooling flow was not lost but the standby pump did start. Unit 3 went in the Track mode because the Integrated Control System (ICS) Main Turbine Control station goes to manual on a loss of Stator Cooling signal. ICS feedwater cross limit alarms were received. At 13:18:01 hours, the Unit Senior Reactor Operator

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(SRO) supervisor restarted 3C CBP in response to the low MFDWP suction pressure. This created a situation with two HWPs and three CBPs running. At 13:18:14 hours, the suction to the CBPs dropped below the trip setpoint. The Unit SRO noticed that the power available indicating light on the 3C HWP control switch was not on, which he assumed meant power was not available. Later, the bulb was determined to be burned out. The Control Room SRO instructed the Control Room Operator to reduce power at 20 megawatts per minute. The Control Room Operator noticed the unit was in Track. He was discussing the situation with the Unit SRO when at 13:18:43 hours, all three of the CBPs tripped due to low suction pressure (

The tripping of the CBPs caused a trip of both MFDWPs that caused an anticipatory reactor trip. The reactor tripped on MFDWP Reactor Protection System (RPS) trip. Three of four RPS channels tripped as required (RPS Channel D was in Bypass).

The response of several systems was specifically affected by the loss of power and the initial conditions of the PT (Degraded Grid, Switchyard Isolation and Keowee Overfrequency Protection Functional Test). Post-trip plant response was as expected for the emergency power lineup. Due to the switchyard alignment, no rapid transfer to the auxiliary buses was possible. Therefore, Unit 3 lost power. The Reactor Coolant Pumps (RCPs) tripped and coasted to a stop. This was a result of the PT that called for the auto/manual transfer switches to be in manual. The Condenser Cooling Water [EHS:BS] system went into the gravity flow mode. The Turbine Driven Emergency Feedwater Pump (TDEFWP) started automatically.

After 21 seconds, transfer to the yellow bus took place. Power was being supplied via the overhead path.

As power was restored, both Motor Driven Emergency Feedwater Pumps (MDEFWP) started. The control system for emergency feedwater began to fill the steam generators (SG) to establish natural circulation cooling of the core. At approximately 1336

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hours, with all indications that both MDEFWPs were operating properly, the Control Operators shutdown the TDEFWP.

Pressurizer level prior to the trip was steady at 220 inches. Just after the trip, pressurizer level dropped to a minimum of 96 inches, then gradually returned to its normal operating level of 220 inches. RCS pressure dropped from 2154 psig to a minimum of 1881 psig, then rose to a maximum of 2151 psig before stabilizing. Hot and cold leg RCS

temperatures pre-trip dropped from 602 and 558 F, respectively, and then stabilized at approximately 576 and 525 F in natural circulation. RCS flow dropped from 72 million lbm/hr/loop as the RCPs coasted down, and stabilized in natural circulation flow of approximately 1 million lbm/hr/loop.

SG startup level was controlling at 198 inches prior to the trip. Following the trip, level dropped to a minimum of 78 inches, and subsequently was restored to 239 inches by emergency feedwater to initiate natural circulation. SG 3A pressure was controlling at 896 psig prior to the trip. The post trip maximum pressure reached was 1072 psig. Pressure later dropped to 771 psig, and stabilized and controlled at 968 psig. SG 33 pressure was controlling at 898 psig prior to the trip, and reached a maximum of 1078 psig after the trip. Pressure then dropped to 772 psig and later stabilized and controlled at 968 psig. As SG level was increased automatically by the EFDW system, a slight overfeed occurred causing the SG pressure reduction. Per procedure, operators placed EFDW control valves in manual to reduce the feed rate and stabilize SG pressure.

In summary, overall plant and emergency power system response was as expected per the test lineup. Control Room personnel safely responded to the trip, and no significant radioactive releases were made to the environment. No ES or pressurizer relief valve actuations occurred, and no RCS leakage was induced.

Approximately forty minutes into the event, a HWP was started with Powdex bypassed in preparation to start a CBP and FDWP. This was performed using the procedure for startup of the

Condensate system. It was discovered later, at approximately 1500 hours, that the gaskets had failed on both Stator Coolers and two Hydrogen Coolers. Powdex resin was observed at the leaks. The Condensate system flow was reduced in an effort to minimize the leaks. An investigation was initiated to determine how the resins entered the Condensate system.

It was determined that a pressure surge in the Condensate system occurred when all the pumps tripped which caused the gaskets to fail.

Within a few hours of the discovery of resin on the turbine floor, the Powdex resin trap was disassembled and inspected. The trap was in very good condition. No path existed which would allow resin to pass through the trap. Therefore, the resin did not enter the Condensate system by passing through the resin trap but entered the Condensate system by flowing backwards out of the Powdex system.

Eight possible flow paths were postulated which could allow reverse flow through the Powdex and thereby move resin out of the Powdex vessels and into the Condensate system.

The flow path that was determined the most likely cause for the resin backflow into the Condensate system was due to the Hydrogen Cooler and Stator Cooler gasket failures. The gasket failures resulted in the system being vented. The Condenser vacuum drew water from the Hydrogen Coolers and Stator Coolers backward toward the Hotwell. This water carried resin out of the Powdex vessels into the Condensate system. A HWP discharge check valve had to fail open for this to occur. In addition, portions of the Condensate appear to have flashed based on

temperature plots of selected Condensate components.

All the failed gaskets were repaired.

Following the Unit 3 trip, Oconee site management requested a Significant Event Investigation Team (SEIT) be formed to investigate this event. The objective was to achieve a timely,

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systematic and technically sound understanding of the event and to ensure that lessons learned from the event would be determined in order to prevent recurrence. A charter for the investigation was approved by site management. An entrance meeting was held with site management on March 17, 1996. Site management was debriefed on the SEIT's preliminary findings on March 21, 1996.

The Degraded Grid, Switchyard Isolation and Keowee Over Frequency Protection Functional Test contained an enclosure for compensatory action if a unit trip or some other problem occurred during the test. This enclosure was used to restore the normal power supply in a controlled fashion.

When steps were reached that restart RCPs in the Subsequent Actions section of the EOP, the 6900V buses on Unit 3 were deenergized. The Degraded Grid, Switchyard Isolation and Keowee Over Frequency Protection Functional Test had placed the Transfer select switches in the manual position. With these switches in manual, the 6900V buses did not transfer to CT-3 when Keowee powered the 230 Kv yellow bus when power was lost.

The controlling procedures at this time were EP/3/A/1800/01 (EOP), AP/3/A/1700/19 (Loss of Feedwater) and AP/3/A/1700/11 (Loss of Power). The operators completed loss of power AP's which recovered from the SWYD Isolation. Keowee was synched to the grid and the yellow bus was connected to the system. Both of the Keowee units were then shutdown and the power supplied to Unit 3 was from the Duke system via the startup source.

At 2055 hours, 3TA and 3TB Startup 6900V feeder breakers were closed and RCPs 3B1 and 3A2 were started at 2112 and 2136 hours, respectively.

The OSM during the previous shift had overlooked making the required four-hour non-emergency notification call to the NRC concerning the unit trip. When this was recognized, the notification was made at 2145 hours.

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At approximately 2300 hours, Management decided to cool down the unit in order to use Low Pressure Injection for decay heat removal to allow for cleanup and repairs of the condensate system and to determine the cause of the event. The RCS was taken to approximately 225 F and 278 psig while utilizing Emergency Feedwater (EFW) with an alignment that minimized the possibility of resin flowing into the SGs.

On March 17, 1996, at 0450 hours, a high vibration alarm was received on the 3B1 RCP motor frame. The 3B1 RCP was secured at 0457 hours, per the alarm response procedure. At 0458 hours, RPS channels A, 3, and C tripped on flux/imbalance/flow (RPS channel D in bypass). There were no control rods withdrawn from the core at this time. The RPS had been

reset at 0415 hours, to allow closing of the Control Rod supply breakers, in preparation of withdrawing Group 1 to 50%. However, the shutdown process had not progressed to the point of withdrawing the rods. This unplanned RPS actuation was reported to the NRC at 0618 hours by a four-hour non-emergency notification call. Maintenance started investigating the vibration problem with the 3B1 RCP. It was concluded that the vibration was transient in nature and did not appear to correlate to any known RCP or motor failure mechanism. There was slightly higher than normal vibration noted during the startup, but continuous monitoring of the pump revealed that as system temperature and pressure increased, the vibration decreased. As the startup continued, the vibration decreased further to within normal limits.

On March 18, 1996, at 1327 hours, the MDEFDWP's were secured after verifying Main Feedwater was properly supplying the SGs.

A formal Failure Investigation Process (FIP) was utilized in the trouble shooting, beginning Sunday, March 17, 1996. This process provides a methodical, structured approach to investigating plant equipment problems and ensures that alternative failure modes are considered and provide documentation of the results. Failed equipment is quarantined and preserved for appropriate failure analysis. The process includes requirements for prompt

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interviews of involved personnel, assurance of qualified personnel to conduct investigations, as well as providing management oversight.

The FIP process had narrowed the possible failure modes of the Degraded

Grid test causing the power loss on 3TE to certain relays of the loadshed circuitry. Trouble shooting of the 3RLS1X, ELS1 and ELS2 relays conducted early March 19, 1996, indicated that very minor movement of the plunger on the 3RLS1X relay caused contact 4F-4Fa to close. This contact is an input to the ELS1 relay, which initiates load shed in the 3TE switchgear.

Undervoltage relays actuating in an adjacent panel were postulated to cause enough vibration to close the contact in the 3RLS1X relay.

A Temporary test TT/0/A/610/21 was developed and performed multiple times on March 20, 1996. This test actuated the undervoltage relays and, in fact, repeatedly caused the contact 4F-4FA in 3RLS1X relay to close momentarily although not for sufficient duration to pick up the 3TE loadshed relay.

The suspect relay was replaced under a temporary installation procedure and Temporary test TT/0/A/610/21A (similar to above test) was run to verify that the replacement relay did not exhibit the same behavior as the previously installed 3RLS1X relay. No contact closure occurred, confirming the root cause.

Oconee received a letter dated March 18, 1996, from the NRC that issued a Confirmation of Action that delineated certain actions required to be taken by Duke Power prior to startup of Unit 3. The NRC letter requested that Duke Power respond in writing when the actions were completed.

On March 22, 1996, Duke Power Management met with the NRC at Oconee to discuss the actions that had been completed and actions that would be taken prior to startup.

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Oconee received permission from the NRC to restart Unit 3 at 1620 hours, on March 25, 1996, after Oconee confirmed that all requested actions had been completed.

On March 26, 1996, at 0114 hours Unit 3 reactor was critical and at 0413 hours the turbine/generator was placed on-line.

CONCLUSIONS

A detailed root cause investigation was performed using the FIP process on the failure mode of this relay. This included detailed troubleshooting of the relay problem and involved a failure analysis expert from the relay supplier. The results of this investigation concluded that the plunger extension which is threaded into the base-plunger when a third or top deck is added to a Cutler-Hammer type M relay, was not adequately threaded into the base assembly. When the top deck is added to the relay, there should be approximately 8.5 turns of the threaded plunger extension to properly seat this assembly. It was found that this assembly was only engaged 7 turns. This resulted in inadequate contact gap for the normally open contacts on the top deck of relay 3RLS1X. As found data for the 4F-4FA contact had the smallest gap that was measured at 5 mils. This resulted in this contact closing when adjacent relays near it in the Emergency Power Switching Logic cabinets changed state. Bench testing revealed that when the plunger assembly was properly engaged 8.5 turns, the top deck contacts had a contact gap of greater than 50 mils.

History of relay maintenance was reviewed and it was determined that this relay had likely been installed in the 1979-1982 time frame. The cause of the inadequate installation of the relay top deck assembly could lie with the manufacturer in that the relay could have been supplied this way or it could have been assembled at Oconee. one of these two is the cause of the relay problem. The reactor trip was caused by a condensate system transient resulting from the load shed of 4KV Bus 3TE. The root cause of the event was determined to be Installation Deficiency due to improper assembly of a relay.

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A contributing cause is the lack of clear guidance criteria for Cutler-Hammer relay installation.

A sample population of three-deck Cutler-Hammer relays will be selected for further inspection to determine whether or not there are other cases of improper installation. An inspection methodology will be developed, the sample population will be inspected, and then based on the findings of the inspection either more relays will be inspected (if problems are found with the initial batch of relays inspected) or no further action will be taken (if no problems are found on initial inspection).

The 3C CBP was restarted by the SRO during the secondary transient. It was concluded that restarting this pump with only two HWP's running most likely resulted in the feedwater pump trip occurring earlier than it would have otherwise.

The Reactor Protective System (RPS) tripped on Flux/Imbalance/Flow (FIF) signal when the Reactor Coolant Pump (RCP) was secured. This occurred

while the plant was at 0% full power, and at temperature and pressure for hot shutdown conditions with two RCPs running and no control rods withdrawn. One of the RCPs was secured due to high vibration. This caused a loss of Reactor Coolant System (RCS) flow in one loop and input a signal to the STAR hardware which drove the analog outputs to 0.0 Vdc.

The RPS trip was caused by the loss of RCS flow condition. The plant is not routinely operated with only 2 pumps at hot shutdown conditions. Normally, if only 2 pumps are running the RPS is in Shutdown Bypass which bypasses the FIF trip. However, the condition (low flow driving all outputs to 0 Vdc) has been recognized as an area for improvement. The STAR hardware vendor is presently working on a firmware revision to address this condition (to not drive the Imbalance signal to 0). This revision will be implemented. Installation of the STAR hardware is a recent modification in the FIF trip string of the RPS.

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Procedure changes will be made as compensatory measures until the improvements are made in the STAR hardware.

A review of previous Oconee operating experience was performed in the areas of relays, condensate/feedwater transients, over-pressurization of secondary components, and resin intrusion to determine if any similar events had occurred that could have prevented or reduced the impact of the event under investigation. A review of internal operating experience over the last two years was performed. This review indicated there were no corrective actions from internal operating experience that could have prevented the Oconee event. Therefore, this event is considered to be non-recurring.

The Cutler-Hammer type M relay is not NPRDS reportable.

CORRECTIVE ACTIONS

Immediate

1. The operators stabilized the unit at Hot Shutdown condition in natural circulation.

Subsequent

1. The Cutler Hammer relay was replaced.
2. The damaged secondary system gaskets were replaced and the Powdex resins were removed from the system.
3. Operation Management's position on Senior Reactor Operators (SROs) operating control room equipment was established and communicated to the operators.

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Planned

1. Develop sample population of Cutler-Hammer relays to be inspected. Develop inspection methodology. Perform inspection of sample population of relays. Determine need for additional corrective actions based on findings of this inspection.

2. Develop and implement clear guidance for proper methods and acceptance criteria for installation and maintenance of Cutler-Hammer relays to ensure proper contact gap clearances are maintained.
3. Revise the Emergency Operations Procedure and the Reactor Trip Review Procedure to include steps for ensuring the required NRC notifications are performed.
4. Modify the Star hardware of the Flux/Imbalance/Flow module of the Reactor Protective System such that it will not generate a trip signal at normal operating modes.
5. Change the appropriate procedures to alert operators that going to a no flow condition in one loop at no power condition will trip the Reactor Protective System.

SAFETY ANALYSIS

Loss of Main Feedwater (MFDW) is an anticipated transient and is described in Section 10.4 of the Final Safety Analysis Report (FSAR). Loss of MFDW initiates a reactor trip and starts the Emergency Feedwater (EFDW) System to provide decay heat removal. In this event, all the systems and equipment operated as designed to mitigate the consequences of the loss of MFDW. The MFDW pumps and Main Turbine (MT) tripped as expected. Instrumentation detected the loss of both MFDW pumps and the MT and initiated the Reactor Trip and provided the start signal to the EFDW system.

All three EFDW pumps started and the unit was stabilized at hot shutdown.

The event has been evaluated with respect to the FSAR accident analyses. The event had only one major occurrence which has been considered with respect to the FSAR accident analyses, and that is the Loss of Offsite power (LOOP).

A LOOP event results in a reactor trip, loss of all secondary pumps (i.e. hotwell pumps and the condensate booster pumps) and the loss of all Reactor Coolant Pumps (RCPs). The FSAR contains a conservative analysis which demonstrates that no safety limits are exceeded, and stable core cooling conditions are achieved and maintained via natural circulation. The Unit 3 event is less severe than the LOOP event analyzed for the FSAR because the LOOP for this event occurred after the unit had tripped and the Standby Bus was already energized by Lee Turbines.

This event has been analyzed for the potential for a core damage accident. The Oconee PRA model has been used in the analysis. This event began with a spurious loss of Main Feedwater (LOMF) Due to the switchyard testing in progress, the reactor/turbine culminated in a plant condition similar to a (LOOP). The LOMF event is included in the PRA as transient T2 and the LOOP most resembles T5FEEDF initiator. The T5FEEDF is a loss of offsite power during which the overhead path from KH is not affected.

Some important mitigating features that were in place during the transient are:

- o A Lee combustion turbine was running and powering the standby buses.

- o Both Keowee units were available.
- o The other Oconee units were available to supply EFDW if needed.
- o The Standby Shutdown Facility was available.
- o Offsite power was "lost" but continuously available via Operator action if desired.

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- o As a precaution of the test, no major equipment was out of service and no maintenance that could pose a risk was underway.

The analysis indicates that for the conditions that existed at the onset of the transient, the conditional probability of core damage for the simultaneous LOMF and LOOP is conservatively estimated to be approximately $3E-07$. The Unit 3 transient did not have a significant potential to proceed to core damage and does not represent an accident sequence precursor.

In summary, this event contained phenomena similar to the FSAR accident analyses, and the event is bounded by the FSAR accident analyses.

There were no releases of radioactive materials, radiation over--exposures, or personnel injuries associated with this event. The health and safety of the public was not affected by this event.

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ATTACHMENT 1 "EMERGENCY POWER DISTRIBUTION" omitted.

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ATTACHMENT 2 "KEOWEE HYDRO STATION AC & DC SYSTEMS" omitted.

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ATTACHMENT 3 "CONDENSATE SYSTEM" omitted.

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ATTACHMENT 4

SEQUENCE OF EVENTS

Oconee 3 Trip Sequence of Events

DATE TIME EVENT DESCRIPTION

3/16/96 13:17:47 4kV Switchgear 3TE loses the following loads:

3C Hotwell Pump (HWP)

3C Condensate Booster Pump (CBP)

3D1 Heater Drain Pump (HDP)

3E1 HDP

3B CCW Pump

MFDW discharge pressure and auction flow

decrease due to loss of CBP and HWP

3C-14 and 3C-15 open (Powdex Bypass), and
standby 3B CBP Starts on low HWP suction
pressure

Unit 3 in Track due to Main Turbine going to
manual due to loss of stator cooling pump

13:17:55 ICS feedwater cross limits alarm

13:18:01 3C CBP restarted by operator

13:18:08 FDWP B Suction press lo 314.45psig

13:18:09 4 kV switchgear startup source voltage normal

13:18:14 CBP Suction pressure drops below emergency
setpoint

13:18:15 CBP Disch HDR Flow Hi 18,497.8 gpm

13:18:20 3C-61 trips open on high AP

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ATTACHMENT 4

SEQUENCE OF EVENTS

DATE TIME EVENT DESCRIPTION

3/16/96 13:18:43.717 Low CBP suction pressure time delay met, all CBPs trip

13:18:43.910 MFDWPs trip due to lose of CBPs Pressure surge in Condensate system ruptures gaskets on hydrogen coolers and into condenser checkvalves. Backflow causes powdex resin backwash

13:18:44.290 RPS Channel B MFW anticipator trip

13:18:44.301 RPS Channel A MFP anticipatory trip-REACTOR TRIP

13:18:44.361 Generator Lockout - power lost to main feeder buses - power lost to all secondary and primary pumps

13:18:44.376 Main Turbine Trip

13:18:45 3B MDEFWP start
3A and 3B HWPs and 3A, B, and C CBPs trip.
Load center MST buses 1 and 2 power failure.
4kV switchgear B1 and B2 normal breakers open.
600 V load center 1 and 2 feeder breakers open.

13:18:45 All control rods inserted - slowest rod 1.279 second drop time

13:18:46.367 3A2 RCP trip

13:18:46.373 3B2 RCP trip

13:18:46.549 3B1 RCP trip

13:18:46.557 3A1 RCP trip

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ATTACHMENT 4

SEQUENCE OF EVENTS

DATE TIME EVENT DESCRIPTION

3/16/96 13:19:05 Power restored to main feeder buses after 21
second breaker delay

13:19:10 EFDWPT starts

13:19:21 3A MDEFWP start

13:49:58 3C CCW pump restarted to
establish forced CCW flow

14:02 to 14:04 3A and 3B HWP and 3A CBP restarted for
condensate recirculation, powdex resin
redistributed through condensate system,
since powdex bypass is open

14:48 Re-established power to all load centers
that were lost due to power failure

15:04 Secured 3B HWP and 3A CBP to minimize
generator hydrogen cooler gasket leaks

16:48 Closed PCB-8, connecting CT3 to the 230 kV red bus

17:38 Exit 72 hour LCO for Tech Spec 3.7.2(1)(1) CT 1, CT2, and CT3 reconnected to yellow bus

18:56 Exit 72 hour LCO for Tech Spec 3.7.2(a)(1) for Keowee overhead

21:12 3B1 RCP restarted

21:36 3A2 RCP restarted

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ATTACHMENT 4

SEQUENCE OF EVENTS

DATE TIME EVENT DESCRIPTION

3/16/96 21:45 Non emergency 4 hour red phone notification made to NRC

23:00 Management decides to cooldown unit in order to use Low Pressure injection (LPI) for decay heat re-oval while investigation in progress and repairs and cleanup of Condensate and FDW Systems.

3/17/96 04:15 Reset RPS; Closed CRD Breakers

04:57:44.425 3B1 RCP secured due to high motor frame vibration

04:58:03.766 RPS trip due to loss of RCS flow in B loop

05:35 3B2 RCP started

05:50 RCS cooldown started using turbine bypass valves

0900 SEIT entrance meeting with Site Mgt.

3/18/96 0920 Low Pressure Injection started for decay heat removal

Oconee received Confirmation of Action letter from NRC

3/20/96 Testing by Engr. confirms relay caused initial load shed of 3TE

3/22/96 Oconee Mgt meets with NRC at Oconee to discuss status

3/24/96 1438 Unit 3 begins heatup and pressurization

3/25/96 1620 NRC permission to continue with startup

received

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ATTACHMENT 4

SEQUENCE OF EVENTS

DATE TIME EVENT DESCRIPTION

3/26/96 0114 Reactor critical

0413 Turbine/Generator on-line

ATTACHMENT TO 9604220352 PAGE 1 OF 2

Duke Power Company

Oconee Nuclear Generation Department J.W. Hampton

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DUKE POWER

April 15, 1996

U.S. Nuclear Regulatory Commission

Document Control Desk

Washington, D.C. 20555

Subject: Oconee Nuclear Station

Docket Nos. 50-269, -270, -287
Licensee Event Report 287/96-01

Gentlemen:

Pursuant to 10 CFR 50.73 Sections (a) (1) and (d), attached is Licensee Event Report, 287/96-01, concerning the loss of feedwater which resulted in a reactor trip due to installation deficiency, improper assembly.

This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(iv). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

J. W. Hampton, Vice President
Oconee Nuclear Site

/fts

Attachment

ATTACHMENT TO 9604220352 PAGE 2 OF 2

Document Control Desk
April 15, 1996

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